

**Proposal title:**

**“Advanced direct biogas fuel processor for robust and cost-effective decentralised hydrogen production” BioRobur<sup>Plus</sup>**



**Topic:** FCH-02-2-2016. Development of compact reformers for distributed bio-hydrogen production

**Funding scheme:** Collaborative project

**Start date of project:** 1<sup>st</sup> January 2017

**Duration:** 42 months



**Deliverable:** 6M coordination and management report, including a disclosable version

**Organisation name of lead contractor for this deliverable:** POLITO

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**Disemmination level:** Public



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## 1. Introduction

The present deliverable “D1.2: 6-month coordination and management report, including a disclosable version” is part of the work package 1 (WP1), which ensure the coordination and management of BioRobur<sup>plus</sup> project. This workpackage is split into two Tasks, both under the responsibility of POLITO. The objectives of the WP1 are:

- Co-ordination, monitoring and reporting of the project
- Administrative and financial management of the project
- Networking activities that will foster exchange with other related projects to identify and ensure potential synergies
- Perform risk/SWOT analyses of the BioRobur<sup>plus</sup> R&D activities
- Conceive contingency plans on a regular basis to maximize chances of success

## 2. Technical progress

The Gantt of the project is provided hereafter. (M0-6) highlighted in orange.

Workpackages and Tasks		Duration (months)						
WP	Task	0-6	7-12	13-18	19-24	25-30	31-36	37-42
<b>WP 1</b>	<b>Project coordination and management (Responsible: POLITO)</b>	0-6	7-12	13-18	19-24	25-30	31-36	37-42
T 1.1	Coordination and management	←→						
T 1.2	Risk analysis and contingency plans conception	←→						
<b>WP 2</b>	<b>Catalysts &amp; catalytic reactors (Responsible: IRCE)</b>	0-6	7-12	13-18	19-24	25-30	31-36	37-42
T 2.1	Concept design of catalytic reactors series	←→						
T 2.2	Catalysts selection, characterisation & optimisation	←→						
T 2.3	Coke formation analysis & detailed modelling, including conception of associated reformer operating strategies	←→						
T 2.4	Structured supports development	←→						
T 2.5	OSR reactor development/adaptation	←→						
T 2.6	Catalytic wall flow reactor development/adaptation	←→						
T 2.7	WGS reactor development	←→						
T 2.8	Detailed design of catalytic reactors series	←→						
T 2.9	Catalytic reactors assembly and precertification	←→						
<b>WP 3</b>	<b>Advanced integrated hydrogen purification (Responsible: HST)</b>	0-6	7-12	13-18	19-24	25-30	31-36	37-42
T 3.1	Purification system concept design	←→						
T 3.2	Sorption materials and fluids selection, characterisation & optimisation	←→						
T 3.3	Detailed modelling & quantification of regeneration strategies	←→						
T 3.4	Evaluation of possible integration with alternative purification routes	←→						
T 3.5	Detailed design of full scale integrated purification system	←→						
T 3.6	Integrated purification system assembly and precertification	←→						
<b>WP 4</b>	<b>Off-gas burner enthalpy valorisation (Responsible: KIT)</b>	0-6	7-12	13-18	19-24	25-30	31-36	37-42
T 4.1	Off-gas burner concept design	←→						
T 4.2	Development of burner structured components	←→						
T 4.3	Detailed combustion modelling & conception of burner operation/control strategies	←→						
T 4.4	Prototype burner assembly and testing	←→						
T 4.5	Detailed design of final off-gas burner including integrated heat transfer systems	←→						
T 4.6	Integrated final off-gas burner assembly and precertification	←→						

WP 5	Complete biogas-to-hydrogen fuel processor (Responsible: HST)	0-6	7-12	13-18	19-24	25-30	31-36	37-42
T 5.1	Fuel processor specifications	←	→					
T 5.2	System modelling and concept design		←	→				
T 5.3	Overall fuel processor detailed design				←	→		
T 5.4	Feed & control system adaptation				←	→		
T 5.5	Procurement/adaption of complementary BOP components				←	→		
T 5.6	Biogas processor assembly and indoor certification				←	→		
T5.7	Biogas processor operation and testing in real environment						←	→
WP 6	Prenormative, LCA, safety and market studies (Responsible: POLITO)	0-6	7-12	13-18	19-24	25-30	31-36	37-42
T 6.1	LCA & prenormative studies		←	→				
T 6.2	REACH and safety analyses		←	→				
T 6.3	Scale-up/marketing and exploitation plan		←	→				
WP 7	Dissemination & Training (Responsible: POLITO)	0-6	7-12	13-18	19-24	25-30	31-36	37-42
T 7.1	Dissemination			←	→			
T 7.2	Training			←	→			

A more detailed study of this progress is provided in the below analysis carried out on a WP basis.

## 2.1. WP1 - Project coordination and management (POLITO)

Prof. Debora Fino (POLITO) is coordinating the project, including technical, research, administrative and financial activities within the framework of the project. Project coordination has run smoothly and in line with the expectations. Within this six months:

- The web site has been opened both in its public and private sections (D1.1).
- The KOM was held in Torino and, during it, explanations between FP7 and H2020 programme were given (indirect costs, reimbursement rates, CFS needed, ecc.)
- The final version of the Consortium Agreement was signed on the 27 January 2017.
- During the 6M meeting held in Lyon last week the coordinator distributed the contract with the original signatures of all partners.

### List of dates and place of the progress meetings:

- Kick off meeting – Torino, 24-25<sup>th</sup> January 2017
- 6M meeting – Lyon (IRCE-CNRS) 10-11<sup>th</sup> July 2017.

Table 1 shows the deliverable due to the Month 6.

Table 1. Deliverables at M6.

Del. no.	Deliverable Title	Responsible Partner	WP	Date
D1.1	Public and private BioRobur <sup>plus</sup> web site opened	POLITO	1	3
D1.2	6-month coordination and management report	POLITO	1	6
D2.1	Report on operating conditions for all catalytic reactions	DBI	2	6
D3.1	Concept design of the H <sub>2</sub> purification unit	HST	3	6
D4.1	Off-gas burner concept and definition of interface conditions	KIT	4	6
D5.1	Plant Specification (process and services)	HST	5	6

Deliverables highlighted in red are slightly delayed due to the changes and improvements that are being made in the BioRobur<sup>plus</sup> plant scheme. In order to reach the project targets, the process flow diagram has been the subject of discussion since the beginning between the partners involved. The final decision of the overall BioRobur<sup>plus</sup> plant scheme with all the plant specifications were decided during the last project meeting at Lyon, France. These deliverables will be submitted within first weeks of September.

## 2.2. WP2 - Catalysts & catalytic reactors (IRCE)

This WP aims to optimize and test all the proposed catalyst formulations with respect to the BioRobur<sup>plus</sup> operating conditions at lab-scale. In addition, optimized structured supports will be developed and the optimized catalyst formulations will be coated onto the supports. The design and assembly of the catalytic reactors for the overall processor will be carried out also within this WP. Coke formation will also be studied at a practical and fundamental level.

This WP comprises 9 tasks as follows:

- T 2.1 Concept design of catalytic reactors series (Involved partners: DBI, SUPSI, JM, IRCE, CPERI; duration: months 1-6)
- T 2.2 Catalysts selection, characterisation & optimisation (Involved partners: IRCE, JM, DBI, MET; duration: months 1-12)
- T2.3 Coke formation analysis & detailed modelling, including conception of associated reformer operating strategies (Involved partners: CPERI, IRCE, JM, DBI; duration: months 4-18)
- T 2.4 Structured supports development (Involved partners: MET, ENGICER, SUPSI, KIT, IRCE; duration: months 1-12)
- T 2.5 OSR reactor development/adaptation (Involved partners: MET, DBI, IRCE, CPERI, ENGICER, SUPSI, JM; duration: months 7-18)
- T 2.6 Catalytic wall-flow reactor development/adaptation (Involved partners: POLITO, CPERI, DBI; duration: months 7-18)
- T 2.7 WGS reactor development (Involved partners: IRCE, DBI, JM; duration: months 7-18)

- T 2.8 Detailed design of catalytic reactors series (Inv. partners: DBI, SUPSI; duration: months 13-18)
- T 2.9 Catalytic reactors assembly and pre-certification (Involved partners: DBI, CPERI; duration: months 16-24)

Tasks 2.1-2.4 already start. Lab scale test rig is ready and the experiments with JM catalysts have been started. IRCE has tested the catalyst developed in Biorobur under the initial Biorobur<sup>plus</sup> conditions (SCR=3, OCR=0.75). The results showed a methane conversion of 100% over 52 h of testing time using high GHSV values. Furthermore, different OCR and SCR values were tested.

During the last meeting (6M) in Lyon, on July 10<sup>th</sup> and 11<sup>th</sup>, the BioRobur<sup>plus</sup> process scheme and the operating conditions were determined in order to meet the project targets taking in account technical and economical aspects.

### **2.3. WP3 - Advance integrated hydrogen purification (HST)**

Within this WP, the most promising process options for hydrogen purification and the related operating conditions are identified. Moreover, the performance of mass-produced adsorbing materials (PSA) and absorption fluids (CHEM and PHYS) under relevant process conditions are identified and deeply characterised.

Other objectives that this WP includes are:

- Conceive and validate models for the design of process sorption and desorption units as well as their operation procedures.
- Continuously evaluate the development of alternative purification routes to consider their integration in case significant technological advances are achieved.
- Selection of the most appropriate H<sub>2</sub> purification process.
- Design and manufacturing of related process units.
- Assembly and pre-certification of the H<sub>2</sub> purification line.

This WP is divided into six tasks as follows:

- T 3.1 Purification system concept design (Involved partners: HST, POLITO; duration: months 1-6)
- T 3.2 Sorption materials and fluids selection, characterisation & optimisation (Involved partners: POLITO, HST; duration: months 1-12)
- T 3.3 Detailed modelling & quantification of regeneration strategies (Involved partners: POLITO, KIT, HST; duration: months 4-18)
- T 3.4 Evaluation of possible integration with alternative purification routes (Involved partners:

- POLITO, KIT, DBI, HST; duration: months 1-12)
- T 3.5 Detailed design of full-scale integrated purification system (Involved partners: HST, ACEA; duration: months 13-18)
- T 3.6 Integrated purification system assembly and precertification (Involved partners: HST; duration: months 16-24)

The identification and selection of the purification process impact directly on the process efficiency. Therefore, within this WP, process simulation of the overall system considering different purification options were studied and discussed to meet the BioRobur<sup>plus</sup> efficiency (80%), at the most convenient CAPEX, which is also a relevant target of the project (cost of H<sub>2</sub>).

The Deliverable 3.1 has been submitted at M6.

#### **2.4. WP4 - Off-gas bruber enthalpy valorisation (KIT)**

The main objective of this WP is to develop the off-gas burner and heat transfer systems, which are required for utilizing enthalpy of the off-gases in the biogas reformer process.

The detailed objectives of this WP are:

- Concept design of an off-gas burner, which ensures a safe operation with the low/varying caloric value gases and exhibits an efficient combustion and low pollutant emissions.
- Development of enhanced structured (ceramic) components for heat exchanger/burner.
- Combustion modelling of sophisticated burner and further development of burner design and burner control strategy.
- Evaluation of the operating range and emission performance by prototype burner experiments.
- Detailed design of final system including the off-gas burner and complete heat transfer system for the thermal integration in the biogas reformer.
- Construction and pre-certification of final components.

According to the objectives of WP4, the burner concept should promote a safe operation with varying off-gas composition as well as low pollutant emissions. The final concept of the burner depends on the definition of the BioRobur<sup>plus</sup> plant scheme. As mentioned before, the final BioRobur<sup>plus</sup> plant scheme was defined during the last meeting, therefore, the off-gas burner is currently being studied.

This work package is divided in six tasks.

- T 4.1 Off-gas burner concept design (Inv. partners: KIT, SUPSI, ENGICER, HST; duration: months 1-6)
- T 4.2 Development of burner structured components (Involved partners: SUPSI, ENGICER, KIT; duration: months 1-24)



- T 4.3 Detailed combustion modelling & conception of burner operation/control strategies (Involved partner: KIT; duration: months 3-24)
- T 4.4 Prototype burner assembly and testing (Involved partners: KIT, SUPSI, ENGICER; duration: months 7-24)
- T 4.5 Detailed design of final off-gas burner including integrated heat transfer systems (Involved partners: KIT, SUPSI, ENGICER, HST; duration: months 13-24)
- T 4.6 Integrated off-gas burner assembly and precertification (Involved partners: KIT, ENGICER, HST; duration: months 16-24)

Tasks 4.1-4.3 have been started and the Deliverable 4.1 has been submitted in time.

### **2.5. WP5 - Complete biogas-to-hydrogen fuel processor (HST)**

This WP is focus on the development of the complete biogas-to-hydrogen fuel processor. It starts with the general system specifications and will be completed with processor operation and testing in real environment at ACEA.

Objectives comprised in this WP are:

- To define the overall system specifications
- To perform conceptual, basic and detailed design
- To define the final control system
- To define and execute the indoor testing and certification procedures
- To define and execute the final testing and operation procedures in real environment.

This work package is divided in seven tasks:

- T 5.1 Fuel processor specifications (Involved partners: HST, DBI, KIT; duration: months 1-6)
- T 5.2 System modelling and concept design (Involved partners: HST, POLITO, KIT, ACEA, JM; duration: months 7-24)
- T 5.3 Overall fuel processor detailed design (Involved partners: HST, DBI, JM; duration: months 19-24)
- T 5.4 Feed & control system adaptation (Involved partners: HST; duration: months 19-24)
- T 5.5 Procurement/adaption of complementary BOP components (Involved partners: HST; duration: months 19-24)
- T 5.6 Biogas processor assembly and indoor certification (Involved partners: HST, DBI, ACEA, KIT; duration: months 22-30)
- T5.7 Demo site preparation and biogas processor operation and testing in real environment (Involved partners: ACEA, HST, DBI, KIT; duration: months 28-42)

The task 5.1 has been completed and the deliverable 5.1 is on going.

## 2.6. WP6 - Prenormative, LCA, safety and market studies (POLITO)

The main objective of the WP6 is to develop the tools that will ensure critical assessment of all issues that relate to the acceptance by the mass market for the BioRobur<sup>plus</sup> system and particularly:

- Assess component and system sustainability.
- Develop decision-making schemes for various stakeholders based on technical-economic-environmental criteria.
- Propose business models for different European regions and associated market plan.
- Demonstrate the overall energy performance of the new BioRobur<sup>plus</sup> system for decentralised biogas conversion into H<sub>2</sub>.
- Identification of exploitation channels for the BioRobur<sup>plus</sup> system.

This work package is divided in the following three tasks:

- T 6.1 LCA & prenormative studies (Involved partners: POLITO, HST, KIT, JM; duration: months 7-42)
- T 6.2 REACH and safety analyses (Involved partners: POLITO, HST, KIT, JM; duration: months 7-42)
- T 6.3 Scale-up/marketing analysis and exploitation plan (Involved partners: HST, ENGICER, ACEA; KIT, JM; duration: months 7-42)

## 2.7. WP7 - Dissemination & training (POLITO)

The work package 7 aims to ensure the dissemination of knowledge generated and to organize training activities in the BioRobur<sup>plus</sup> project. This WP is split in two tasks:

- Task 7.1. Dissemination (Involved partners: POLITO, all partners; duration: months 3-42)
- Task 7.2. Training (Involved partners: POLITO, IRCE, KIT, CPERI; duration: months 13-42)

The plan for exploitation and dissemination of the results of BioRobur<sup>plus</sup> project, which will be updated during the project's lifecycle and beyond has been presented in the Deliverable 7.1.